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Report No. TOR-0158(3107-15)-11, Reissue A

STRUCTURAL SPECIFICATION GEMINI B SPACECRAFT

Prepared by

Gemini B Systems Engineering Directorate
MOL Systems Engineering Office

AEROSPACE CORPORATION

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October 1968

This Report Supersedes
and Replaces TOR-0158
(3107-15)-11, June 1968

Prepared for DEPUTY DIRECTOR
MANNED ORBITING LABORATORY PROGRAM
MOL SYSTEMS OFFICE, OSAF
HEADQUARTERS, SPACE AND MISSILE SYSTEMS ORGANIZATION
Air Force Unit Post Office
Los Angeles, California 90045
Contract No. FO4 701-68-C-0200
Contract No. F04695-67-C-0158

[redacted] [redacted]

[redacted]

Aerospace Report No.
TOR-0158(3107-15)-11
Reissue A

STRUCTURAL SPECIFICATION, GEMINI B SPACECRAFT

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The information in a Technical Operating Report is developed for a particular program and is therefore not necessarily of broader technical applicability.

CONTENTS

TABLES

GEMINI B SPACECRAFT STRUCTURAL SPECIFICATION

1.0 INTRODUCTION

1.1 Scope

This document presents the basic requirements governing the structural design for the Gemini B Spacecraft of the Manned Orbiting Laboratory System (MOL).

Included herein are the following:

1. Definitions, Abbreviations, and References.
2. Structural Design Philosophy.
3. General conditions and environments for which the Spacecraft Structure must be evaluated and/or designed.
4. Requirements for establishing loads and other environmental factors for the structural design conditions.

1.2 Purpose

This document shall govern the design of all the Gemini B Spacecraft structural components. The Contractor shall prepare definitive structural design criteria to implement the requirements of this specification.

2.0 DEFINITIONS, ABBREVIATIONS AND REFERENCES

2.1 Definitions

Burst Pressure - Burst pressure is the pressure which a pressure vessel must sustain as a singular load condition, without rupture. Burst pressure is the maximum operating pressure multiplied by the appropriate safety factor.

Conditions - The definitions of the combination of natural and induced environments, based on the structural design criteria, which uniquely establish the structural design or re-analysis requirements.

Failure - A structure is considered to have failed when it can no longer perform its intended function. Failure of structure may result in the loss of the vehicle, or any part thereof, and/ or could present a hazard to operating personnel.

Induced Environment - The influences surrounding and affecting the development of loads, temperatures, and other structural design requirements due to vehicle responses created by the interactions of the natural environments and the vehicle characteristics.

Limit Heating Effects - Temperatures or heating rates which the structure is expected to experience during a design mission.

Limit Load - The maximum load, or combination of loads, which the structure is expected to experience in a specific condition.

Load Factor - Load factor in a given direction is the summation of all of the externally applied forces in that direction divided by the weight.

Margin of Safety - The residual load-carrying capability of a structure above ultimate loads.

Natural Environment - The influences surrounding and affecting the development of loads, temperatures, and other structural design requirements that exist in nature, independently of the existence of a vehicle.

Pressure Vessels - Pressure vessels are defined as containers that must sustain an internal pressure; for example, pressurized cabin, propellant tanks, solid rocket motor cases, nozzles, thrust chambers, liquid or gas storage bottles, plumbing, tubing and piping; but not adapters, interstages, skirts, or fins.

Proof Pressure - That pressure which is applied to a pressure vessel as test evidence of satisfactory workmanship and material quality. Proof pressure is derived by multiplying maximum operating pressure by the proof pressure factor.

Re-analysis - The analysis performed on an existing vehicle or part of an existing vehicle to determine compliance with specific vehicle structural design criteria.

Requirements - The values of specific parameters, such as loads and temperatures, which satisfy the conditons derived from the structural design criteria, and used to define or re-analyze the vehicle structural configuration.

Structural Design Criteria - The standards or rules by which judgments are formed relative to the conditions and resulting structural requirements needed for the structural design or re-analysis of a vehicle such that the vehicle will meet the performance specification requirements.

Factor of Safety - Ratio of allowable load (or stress) to limit load (or stress) at the temperature which defines the allowable, and is used to account for uncertainties and variations from item to item in material properties, fabrication quality and details, and internal and external load distributions.

Ultimate Heating Effects - Limit heating effects with additional heating rate factors or temperature increments to account for the effects of dispersions and/or analytical uncertainties.

Ultimate Load - The product of the factor of safety times limit load.

Critical Condition - A loading or temperature condition, or combination thereof, which dictates the design of a portion of the structure.

Excessive Deformation - Elastic or inelastic deformations resulting from application of limit loads and limit temperatures, are excessive when any portion of the vehicle structure can no longer perform its intended function.

Nominal Pressure - The rated operating pressure of the system.

Maximum Expected Operating Pressure (MEOP) - The maximum anticipated operating pressure including the effects of temperature, transient peaks, and variations in pressure and vehicle acceleration.

Limit Pressure - Same as MEOP above.

Transportation, Handling, and Storage Phase - This phase covers the period following acceptance at the manufacturing facility prior to installation of equipment at MOL Launch Site (MLS).

Pre-Launch Phase - This phase covers the period from arrival of AVE at VAFB to start of countdown. This phase includes assembly of the FV at the launch pad where checkout and countdown will be conducted.

Launch Phase - This phase covers the period from start of countdown to FV liftoff (exclusive).

Ascent Phase - This phase covers the period from FV liftoff (inclusive) to initiation of the T-III M/OV severance ordnance (exclusive).

Orbit Phase - The orbit phase covers the period from initiation (inclusive) of the T-III M/OV severance ordnance to initiation of severance of the Gemini B from the LV (exclusive).

Re-entry Phase - For the manned-automatic configuration this phase covers the period from initiation of severance of the Gemini B from the LV (inclusive) to Gemini B reentry module (REM) splashdown (inclusive). This phase includes retrofire, reentry, parachute deployment, touchdown of the REM, and the detached portion of loiter. The loiter phase covers the period from the initiation of autonomous operation of the Gemini B Environmental Control System (ECS) or electrical system through severance of the equipment section of the Gemini B adapter.

Retrieval Phase - The retrieval phase starts with the Gemini B REM splashdown and ends when the crew, data, and REM are recovered and delivered to predetermined locations for the initiation of postflight analysis. Retrieval includes location of the REM, physical recovery of the REM, crew, and mission data, and initial medical examination and initial debriefing of the crew.

Abort Phase - The abort phases shall include all operations required to return the crew safely to earth subsequent to a malfunction which requires termination of the mission

2.2 Abbreviations

F	=	Fahrenheit
g	=	acceleration due to gravity
fps	=	feet per second
in-lb	=	inch pound(s)
lb	=	pound(s)
psf	=	pound per square foot
psi	=	pound per square inch

2.3 Reference Documents

1. SAFSL Exhibit 12003 - Gemini B environmental and Test Requirements.

2. MIL-HDBK-5 - Strength of Metal Aircraft Elements, Dated August 1962, Revision, November 1964.

3. CP58A010 A - Gemini B Spacecraft Contract End Item Specification.

4. SAFSL Exhibit 10012- Design Loads for the MOL Orbiting Vehicle.

5. MIL-HDBK-17 - Plastic for Flight Vehicles

3.0 DESIGN REQUIREMENTS

3.1 General Design Philosophy

The structure shall possess sufficient strength, rigidity, and other characteristics required to survive the critical loading conditions and environments that exist within the envelope of mission requirements. It shall survive these conditions and environments in a manner that does not reduce the probability of successful completion of the mission below the prescribed limit.

Consistent with the structural design principles and assumptions listed herein, the structure shall be designed to achieve minimum weight. Consideration shall be given to the effect on system cost and development schedule. It shall be an objective that the nonflight conditions and environments shall not increase the flight weight over that required for the flight conditions.

The environment corresponding to each design condition shall include all factors that influence the structural design and typically include heating, vibration, shock, and acoustics, in addition to quasi-static and dynamic loads. Consideration shall be given to the deteriorating effect of prolonged exposure to the space environment.

3.1.1 External and Internal Load Distribution

External loads shall be determined by conservative analyses of the design environment. The aerodynamic loads may be determined from wind tunnel tests or calculated by conservative methods considered to be sound engineering practice. The effects of aeroelasticity on the distribution and magnitude of loads shall be considered.

The internal structural load distribution shall consider the effects of deformations, nonlinearities, and temperature.

3.1.2 Combined Loads and Internal Pressure

When internal pressure effects in combined load conditions are stabilizing

or otherwise beneficial to structural load capability, the nominal internal operating pressure for that condition shall be used instead of the ultimate design internal pressure in the loads analysis.

3.1.3 Misalignment and Dimensional Tolerances

The effects of allowable structural misalignments, control misalignments, and other permissible and expected dimensional tolerances shall be considered in the analysis of all limit loads, loads distributions, and structural adequacy.

3.1.4 Dynamic Loads

Dynamic loads shall be considered for all quasi-static and transient phenomena expected in each design condition. The consideration of dynamic loads shall include the effects of vehicle structural flexibilities and damping and coupling of structural dynamics with the control system and the external environment.

3.1.5 Load and Thermal Fatigue

The effects of repeated loads and temperature cycling shall be considered in the structural design. The design structural adequacy of the vehicle in flight shall not be impaired by fatigue damage resulting from exposure to nonflight and launch environments.

3.1.6 Vibrational and Acoustical Loadings

The effects of the vibrational and acoustical environments shall be considered in the structural design.

3.1.7 Deformations

No excessive structural deformations, including those due to creep, shall be permitted.

3.1.8 Thermal Stresses

The effects of thermal stresses shall be combined with the appropriate load stresses when calculating required strength.

3.2 Material Properties and Allowables

Material strengths and other mechanical and physical properties shall be selected from MIL-HDBK-5, MIL-HDBK-17, Government Specifications, supplier guaranteed properties, or from Contractor test values.

Allowable material strengths used in the design shall reflect the effects of load, temperature, and time associated with the design environment, either individually or in combination, as applicable. The following additional factors shall be considered in selecting material allowables:

1. Criticality of loading
2. Probability of load occurrence
3. Single versus multiple load path
4. Minimum margin of safety

When identifiable, 90 percent probability values shall be used.

3.3 Strength Requirements

3.3.1 At Limit Load

The structure shall be designed to have sufficient strength to withstand the limit loads resulting from aerodynamic pressures, inertia forces, limit heating effects, etc., which combine at any one time without experiencing plastic deformation or excessive elastic deformations. Limit loads shall also be combined with ultimate heating effects to produce an ultimate design condition.

3.3.2 At Ultimate Load

The structure shall sustain the ultimate loads resulting from aerodynamic pressures, inertia forces, limit heating effects, etc., which combine at any one time.

3.3.3 Margin of Safety

Margin of safety is defined as $MS = 1/R - 1$, where R is the ratio of ultimate loads (or stress) to the allowable load (or stress). In determining the factor R, the effect of combined loads or stresses (interaction)

and temperature shall be included.

For minimum weight, the structural design shall strive for the smallest permissible margins of safety, which shall be zero, except in specific instances where finite values may be required.

3.4 Stiffness Requirements

3.4.1 Limit Conditions

The structure shall not experience permanent deformation at limit conditions.

3.4.2 Ultimate Conditions

Structural deformations shall not precipitate structural failure during any design conditions equal to or less than ultimate.

3.4.3 Aeroelastic Requirements

Destructive flutter or related dynamic instability or divergence phenomena shall not occur on the spacecraft at any condition along the design trajectories.

3.4.4 Internal Support Structure

The basic chassis of the components and the immediate support structures shall be capable of preventing excessive dynamic amplification, which would result in a vibration environment in excess of the equipment qualification test levels.

3.5 Thermal Requirements

The effects of temperature shall be considered in design of the spacecraft. Thermal analysis shall be based on transient effects of heat fluxes from sources such as aerodynamic heating, solar and earth reflected radiation, engine system and electronic equipment, including consideration of the heat sink effect of the mass of structure, fluids, and equipment. Aerodynamic heating shall be based on the design heating trajectories.

3.5.1 Limit Heating Effects

Limit heating effects shall be determined by the following procedures:

1. Limit heating effects during the ascent phase shall be obtained using maximum aerodynamic heating trajectory which includes dispersions.
2. Limit heating effects during re-entry shall be obtained by using the design re-entry trajectories.

3.5.2 Ultimate Heating Effects

Ultimate heating effects shall be determined by the following procedures:

1. For outer mold line and adjacent structure, (REM and Adapter), increase the limit temperature by 100°F for ascent phase.
2. For outer mold line and adjacent structure, (REM only), increase the limit temperature by 200°F or increase the heat inputs by 15 percent whichever is critical, for re-entry.
3. Structure inside the REM pressure vessel which is not attached to the skin and has no significant thermal mass shall be designed for 250°F ultimate.
4. Structure inside the REM which is attached to the skin and/or has significant thermal mass, the limit design temperature shall be increased by 25 percent on the Fahrenheit scale.

Ultimate heating effects shall be used with limit loads when effects of the trajectory dispersions are not included in the analyses and significant uncertainties in thermal analyses exist.

3.6 Factors of Safety

The ultimate loads shall be limit loads multiplied by the applicable factors of safety from Table 3.6-1.

3.7 Pressurization Requirements

For structural design, the cabin pressure shall be 12.0 psi ultimate (burst) and 3.0 psi ultimate (collapsing), and the Gemini B segment of

the crew transfer tunnel pressure shall be 12.0 psi ultimate (burst) and 0.5 psi limit (collapsing).

The design of pressure containers, rocket motor cases, and pyrotechnics shall be based on the following requirements except where otherwise stated below:

1. Yielding shall not occur under proof pressure combined with limit temperature.
2. Failure shall not occur under burst pressure combined with limit temperature.
3. Failure shall not occur under the pressure resulting from an ultimate temperature condition when combined with that ultimate temperature.

Design proof and burst factors are summarized in Table 3.7-1. These factors apply to the maximum operating pressures at the design limit temperature and are not applicable at ultimate temperature. For the Re-entry Control System and Environmental Control System pressure containers the pressure system design factors shall apply at room temperature.

3.8 Controls Requirements

The design loads for control handles, levers, and knobs shall be as shown in Table 3.8-1.

3.9 Spacecraft Design Weights Requirements

The weights to be used for structural design of the spacecraft are specified in Table 3.9-1. The maximum and minimum weight for each mission phase accounts for variations and growth of the spacecraft. The weight within this range resulting in maximum loading conditions shall be used.

4.0 MISSION PHASES

4.1 Transportation, Handling and Storage Phase

Structural design shall include consideration of all environments to which the structure and its component parts are exposed during manufacture, handling, transportation, and storage, as specified in SAFSL Exhibit 12003.

4.2 Pre-Launch Phase

The spacecraft shall be capable of sustaining all design load conditions as specified in SAFSL Exhibit 10012 and the environments which may be experienced during the launch operation, specified in SAFSL Exhibit 12003.

4.3 Launch Phase

The spacecraft shall be capable of sustaining all design load conditions as specified in SAFSL Exhibit 10012 and the environments which may be experienced during the launch operation, specified in SAFSL Exhibit 12003. Consideration shall be given to the loading and environment induced by abort during this phase.

4.4 Ascent Phase

The spacecraft structure shall be capable of withstanding the ascent phase environments specified in SAFSL Exhibit 12003 and design loads conditions as specified in SAFSL Exhibit 10012.

The structural requirements of the spacecraft shall be based on the following:

1. The MOL design ascent loads trajectories and maximum aerodynamic heating trajectory.
2. The structural/dynamic characteristics of the Laboratory Vehicle and Launch Vehicle.
3. Lift-off transient loads.
4. Interaction of launch vehicle acceleration and maneuver requirements with atmosphere, wind and gust environments.
5. Adapter and Laboratory venting requirements.
6. Stage burnout and/or thrust termination and engine ignition transient loads at staging.

7. Effects of activation and use of load relief after lift-off.

8. Effects of switching to secondary back-up guidance and control system in the event of malfunction of the primary system.

9. Effects of buffet, flexibility, and dispersion from design trajectories.

4.5 Orbit Phase

The spacecraft shall be capable of withstanding the environments specified in SAFSL 12003, and loads associated with orbital flight as specified in SAFSL 10012.

The structural requirements of the spacecraft shall be based on the following:

1. Orbiting Vehicle Maneuvering
The spacecraft shall be capable of sustaining the loadings and temperatures encountered during the on-orbit phase as the result of the orbital maneuvers performed using the Orbiting Vehicle propulsion system. The design requirements for this phase shall consider the maximum accelerations and rates available from thrust and control systems.

2. Loiter
The spacecraft shall be capable of sustaining the loadings and temperatures encountered during the loiter period which result from maneuvering after the Gemini B has separated from the Laboratory Vehicle and prior to separation of the equipment section of the adapter.

3. On-Orbit Thermal Limitation
The spacecraft shall be capable of sustaining the temperatures associated with Beta (β) angles between $+60^{o}$ and -60^{o}, and the orbit parameters defined in CP58A010A. The angle Beta is defined as the geocentric angle between the earth sunline and the orbital plane.

4. Meteoroid Environment

The capability of the spacecraft to resist destructive meteoroid penetration shall be evaluated relative to the meteoroid environment specified in SAFSL 12003. A destructive penetration is one which impairs the function of the punctured element. The formulae for calculating the meteoroid mass and probability of impact on the spacecraft shall be as specified in SAFSL 12003.

5. Radiation Environment

The effects of both natural and artificial radiation environment shall be evaluated. The radiation environment is specified in SAFSL 12003.

4.6 Re-Entry Phase

The Re-Entry Module (REM) structure shall be capable of withstanding loads and temperatures resulting from controlled re-entries from the orbits specified in CP 58A010A. The REM structure shall be capable of withstanding the loads and temperatures resulting from re-entry from the abort boundaries as specified in CP 58A010A.

The design trajectories for re-entry from orbit and re-entry from ascent phase abort boundaries shall consider the following significant parameters:

1. Altitude, velocity, flight path angle and lift condition for re-entry from various points in orbit for normal re-entry and ascent abort re-entry.
2. Critical combinations of weights and center of gravity which occur within the range of design values.

The descent and landing portions of the re-entry phase shall include operations starting from the initiation of the recovery system deployment and lasting until the REM touchdown. It shall include drogue chute deployment, pilot parachute deployment, main parachute deployment, steady state descent, and surface contact considerations.

The structural requirements of the three parachute systems are specified in Table 4.6-1.

The REM shall be designed for water landing and have the capability to remain afloat in a sea state of 3 or less for at least 36 hours. The water landing loads shall consider the effects of combinations of horizontal velocity, wave slope, and yaw angle combined with heatshield bondline temperature.

Re-Entry design loads are specified in SAFSL 10012.

4.7 Retrieval Phase

The REM shall be capable of sustaining all design load conditions as specified in SAFSL Exhibit 10012 due to hoisting, transportation, and various operations during the retrieval phase, as specified herein.

4.8 Abort Phase

During launch and ascent phase aborts the spacecraft shall be capable of withstanding loads as specified in SAFSL Exhibit 10012 resulting from and subsequent to separation from the Laboratory Vehicle. The ejection seat system shall be used when the main recovery system cannot be deployed (either due to insufficient altitude, or a malfunction) or when land landing is imminent. The ejection seats shall be designed for all conditions resulting from these operations. During seat ejection the re-entry module structure surrounding the crew members shall maintain integrity with hatches open until both astronauts are clear.

5.0 Implementation

For implementation of Paragraph 1.2 and the general philosophy of Paragraph 3.1, it is understood that the terms and conditions of this contract were negotiated on the basis that the design of the Gemini B spacecraft re-entry module structure would remain unchanged from the NASA Gemini design except for modifications to accommodate crew transfer, and that the adapter structure would be designed to withstand preliminary ascent loads as developed by the contractor on the basis of structural design criteria contained in Contractor's Report No. E-168,

dated 15 September 1966. In the event it becomes necessary for the Government to specify final leads which are in excess of mutually agreed predictions of spacecraft structural capabilities, the contractor shall be entitled to an equitable adjustment pursuant to the "Charges" clause of this contract.

TABLE 3.6-1

FACTORS OF SAFETY

PHASE	FACTOR OF SAFETY
Pre-Launch Hoisting and Recovery Hoisting after water landing	1.4 Limit load factors are specified in Table 3.6-2
Transportation	Ultimate load factors are specified in Table 3.6-2
From Stage O Ignition through water landing except as specified in this table	1.4
Water Landing	1.0
Crew Hatch	1.1
Crew Hatch Actuator	1.25
Drogue Parachute Support Structure	
Normal Mission	1.4
Failure of Attitude Control System	1.1
Personnel Parachute Canopies	1.1
Abort Re-entry Afterbody Shingles	1.0
Spacecraft structures and components for abort loads. Resulting from and subsequent to separation from the Laboratory Vehicle.	1.0

TABLE 3.6-2

TRANSPORTATION AND HOISTING LOAD FACTORS

PHASE	LOAD FACTOR
Pre-Launch Hoisting and Recovery Hoisting after water landing	limit load factor is 2.0 (pre-launch) limit load factor is 3.0 (capsule plus trapped water recovery)
Transportation	Ultimate load factors are specified as follows: + 6.0g vertical $\pm$ 2.25g lateral - 3.0g longitudinal (with reference to carrier axes)

TABLE 3.7-1

GEMINI PRESSURE SYSTEMS DESIGN FACTORS

Pneumatic	Operating (LIMIT)	Proof(% Limit)	Burst(% Limit)
Lines, fittings, hoses and actuating cylinders which act as reservoirs	100%	200%	400%
Gas reservoirs	100%	167%	222%
Actuating cylinders and other components	100%	150%	250%
Fluid (1)			
Lines, fittings, hoses	100%	200%	400%
Reservoirs, tanks	100%	200%	300%
Heat exchangers & cold plates	100%	150%	250%
Water storage tanks (ECS)	100%	167%	250%
Fuel and Oxidizer			
Lines, fittings, hoses	100%	200%	400%
Tanks	100%	150%	200%
Rocket Motor Thrust Chamber			
	100%	110%	140% (2)
Pyrotechnic Actuator	100%	120%	150%

NOTES:

(1) For emergency operation the burst factor for components of the temperature control fluid loop shall be 185% of the emergency operating pressure.

(2) These factors apply to maximum ignition or maximum chamber pressure.

TABLE 3.8-1

CONTROLS LOADS

	Controls	Limit Load With Reaction At: Stops	Limit Load With Reaction At: Switches or Valves
PRIMARY CONTROLS	**Attitude Control Grip**		
	Pitch Moment	133 in. lb.	Sufficient to create 100 lbs. minimum at switches
	Side (Roll)	100 lb.	
	Twist (Yaw)	133 in. lb.	
	(Pitch and yaw loads are referenced to Grip Pivot axis and Side Loads are referenced to center of grip.)		
	Abort Handle		
	Side Fore/Aft	$50 \times \left(\frac{1 + \text{lever length}}{3}\right)$ lb. 50 lb. min. to 150 lb. max.	Sufficient to create 100 lbs. minimum at switches
	(Loads are referenced to center of knob.)		
	Maneuvering Handle		
	Vertical, Side and Fore/Aft	$50 \times \left(\frac{1 + \text{lever length}}{3}\right)$ lb. 50 lb. min. to 100 lb. max.	Sufficient to create 100 lbs. minimum at switches
	(Loads are referenced to center of knob in unstowed position.)		
	Environmental Controls		
	Levers	$50 \times \left(\frac{1 + \text{lever length}}{3}\right)$ lb. 50 lb. min. to 100 lb. max.	3 times the pilot operating load but not less than 70 lb. or less than that sufficient to create 100 lbs. minimum at valves.
OTHER CONTROLS	Levers	$50 \times \left(\frac{1 + \text{lever length}}{3}\right)$ lb. 50 lb. min. to 150 lb. max.	Not applicable
	(Loads are referenced to center of grip or knob.)		
	Push-Pull Handles	100 lbs.	Not applicable
	(Loads are referenced to center of knob or ring.)		
	Rotating Knobs	Not applicable	100 in. lbs.
	(Load is not applicable to knobs operating electrical switches.)		

GEMINI B DESIGN WEIGHTS

	CONFIGURATION	MAXIMUM	MINIMUM
*	Ascent	6700	6150
*	On-orbit - Less Crew	6230	5670
	On-orbit Separation	6700	5920
	On-orbit Retro-Grade	6130	5320
	On-orbit Retro-Grade Fired	5840	5050
	Re-Entry	5000	4370
	Drogue Chute Deployment - Includes Recovery Section and Chutes	4945	4330
	Parachute Deployment - Includes Main Chute	4670	4050
	Landing - No Chutes	4560	3940
	Recovery - Includes Trapped Water	6800	--
	Abort Retro-Grade - Ascent Phase	5850	5350
	Abort Re-Entry - Ascent Phase	4760	4420
	Transportation	6450	--

*The weight of the blastshield which is a separate structure located between the Gemini B Adapter and the Laboratory Vehicle is included in the weights. The maximum and minimum design weights of the blast shield and components mounted thereon are 250 and 200 pounds, respectively.

TABLE 4.6-1

PARACHUTE LANDING SYETEM

PARACHUTE	TYPE	DIAMETER (FEET)	TYPE OF RE-ENTRY	DEPLOYMENT ALTITUDE (FEET)	REEFED	LIMIT LOAD (LBS.) Note (2) Note (3)	MAXIMUM PULL OFF ANGLE (DEG.)
Drogue	Conical	8.3	Normal	50,000	Yes	3,500	90°
			Abort	40,000			
Pilot	Ring Sail	18	All	10,600	Yes	4,700	20°
Main	Ring Sail	84	All	Note (1)	Yes	16,000	90°

NOTES: (1) 2.5 seconds after pilot parachute deployment

(2) Gemini B Limit Loads are based on a dynamic pressure (q) of 120 psf

(3) Ultimate dynamic pressure (q) for parachutes is 180 psf.